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Studies in Bacteriological Meat Inspection

I.—The Use of Plating Methods for the Detection of Non-specific Infection in Animal Tissue

BY

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SUMMARY.—1. A comparison is made of the plating methods which may be used in the routine demonstration of non-specific infection for the purposes of bacteriological meat inspection. The method finally adopted is as follows:—

Inoculation of 1- to 2-g. samples of finely cut, but not severed, tissue into tubes of melted and cooled blood agar, followed by mixing and plate pouring. Plates are incubated for 48 hours at 37° C.

At the same time 1- to 2-g. samples are inoculated for shake culture into 1 per cent. glucose agar and incubated for 24 hours at 37° C. Subcultures are made from embedded tissue when tubes show no growth and whenever plating methods fail to reveal infection.

2. The application of these techniques to the bacteriological examination of "normal" animal tissue is described. By these means, 15 per cent. of muscle samples, 26 per cent. of spleen samples, 35 per cent. of samples from prescapular lymph nodes, and 95 per cent. of liver samples were found infected with non-pathogenic bacteria.

3. Standards are suggested for the application of these results to routine bacteriological meat inspection.

Introduction

IN countries which practise bacteriological meat inspection there is clear evidence that the procedure is indispensable to rational and economically sound carcase judgment. The chief advantage may be, as in Germany, to act as one safeguard against the consumption of Salmonella-infected meat (Schönberg, 1951); or, as in Denmark, where the incidence of salmonellosis in meat animals is low, to permit the release of non-infected carcases which may otherwise have been condemned (Lange, 1955; Albertsen, 1956). A review of the background to bacteriological meat inspection based primarily on the work of Standfuss (1952) and Jepsen (1954) has already appeared in British veterinary literature (Olivant, 1957a).

In general, any scheme for the bacteriological study of suspect carcases must involve three procedures:—

1. Examination for a few species of pathogenic bacteria by means of selective or enrichment media.
2. Examination for anaerobic bacteria.
3. A study of the aerobic bacterial flora by means of fluid media, or the use of a plating technique.

There is considerable variation between countries in the methods adopted to fulfil these requirements (Olivant, 1957b), and although the need is recognised (Proceedings, 1956), so far there has been no attempt to formulate a uniform approach. In the first two procedures, for example, there is great diversity in the media used, with no clear evidence on the most suitable; and the use of selective media seems in any case to be generally restricted to the search for Salmonella. In the case of the last procedure, there is disagreement on the significance attached to the mere presence of non-pathogenic organisms as revealed by growth in fluid media, without further reference to the degree and distribution of the non-specific infection. In this connexion many hold that the use of a plating technique has an obvious advantage—although there is again no agreement on the most appropriate technique to use. Clearly, technical differences of this kind contribute to differing standards of carcase judgment, and especially is this so when infection of tissue is restricted to a few non-pathogenic species.

This paper deals with only one of these problems; namely, a comparative study of the plating techniques which may be used in bacteriological meat inspection, and with the application of the most suitable technique to the examination of "normal" animal tissue. It is thus chiefly concerned with the problem of non-specific infection, and it forms part of a wider study of bacteriological meat inspection as applied to British conditions.

Part I

Plating Techniques

Materials

Test organism. A strain of *B. cereus* isolated from a "blown" can of "pasteurised" ham. The organism grew poorly under anaerobic conditions, but produced typical colonies surrounded by a wide zone of haemolysis, after incubation aerobically for 24 hours at 37° C. on 5 per cent. sheep blood agar. Suspensions of washed cells were non-pathogenic for rabbits.

Experimental animals. Large adult rabbits of approximately equal weight from the heterogeneous stock maintained in the Department.

Media. 5 per cent. sheep blood agar; one per cent. glucose agar.

Methods of Study

1. In the first instance, 3 groups of 5 rabbits each were inoculated intravenously with 1.0 ml. of a saline suspension of washed cells of the test organism standardised to the opacity of Brown's tube No. 10. Groups of 5 rabbits were killed at intervals of 1, 7, and 14 days after inoculation, and their tissues removed for cultural examination by the techniques described below.

2. At a later stage two rabbits were inoculated as before, killed 7 days after inoculation, and their livers removed for replicate cultural examination.

The cultural techniques in use were as follows:—

(a) Loop inoculation from tissue to the surface of a blood agar plate.

(b) Tissue smear inoculation, made by rubbing 1 g. of crushed tissue over the surface of a blood agar plate ("German method").

(c) Inoculation of 1 g. finely cut, but not severed, tissue into bottles of melted and cooled blood agar, followed by mixing and plate pouring ("Danish method I").

(d) Crushing and smearing 1 g. tissue over the bottom of a petri dish, followed by the addition of melted and cooled blood agar ("Danish method II").

(e) Trituration of 1 g. tissue in a Griffiths' tube followed by the addition of melted and cooled blood agar and plate pouring.

In the case of (c) (d) and (e) pieces of tissue remained embedded in the medium throughout the incubation period.

Colony counts were made on all tissues after 24 hours' incubation at 37° C.

(f) In addition, 1-g. samples of all tissues were inoculated for shake culture into tubes of one per cent. glucose agar. After overnight incubation at 37° C. subcultures were made from tissue remaining embedded in the medium on to a series of blood agar plates.

Results

It was possible in the first instance to make a roughly quantitative comparison of different plating techniques when used for the examination of tissue of varying bacterial load, and at a later stage, to study a few of the techniques in more detail. Where the use of a plating technique alone failed to demonstrate infection, subculture from the tissue remaining embedded in the glucose media afforded a second opportunity of demonstrating its presence.

Table I shows the comparative efficiency of the plating methods in revealing infection at varying intervals after inoculation. Results are given in terms of the numbers of plates showing well-isolated colonies, and the mean colony count obtained with each technique.

The distribution and course of the infection over a 14-day period were what one expected to result from the intravenous inoculation of a non-pathogenic bacterium. All techniques were effective in revealing infection in its very early stages. However, the quantitative differences between the results of the various methods which were apparent on the first day after infection, became more marked after the lapse of 7 days, at which time the loop method was totally ineffective in demonstrating infection, and the German method significantly less sensitive than the remainder. The results at this stage showed little advantage between the use of either the Danish, or tissue grinding techniques, and the slightly higher mean counts which

TABLE I

NUMBER OF POSITIVE PLATES AND MEAN COLONY COUNT PER G. OF RABBIT TISSUES EXAMINED BY DIFFERENT TECHNIQUES 1, 7 AND 14 DAYS AFTER INFECTION

Number of rabbits	Tissue	Loop			German			Danish I			Danish II			Tissue grinding		
		Day of Examination														
		1	7	14	1	7	14	1	7	14	1	7	14	1	7	14
5	Liver	5(7)	0(0)	0(0)	5(76)	2(1)	0(0)	5(300)	4(9)	1(1)	5(300)	5(10)	2(1)	5(>300)	5(14)	3(4)
5	Spleen	5(6)	0(0)	0(0)	5(69)	2(1)	0(0)	5(300)	5(10)	1(1)	5(300)	5(13)	2(5)	5(>300)	5(16)	3(6)
5	Kidney	5(2)	0(0)	0(0)	5(4)	0(0)	0(0)	5(100)	0(0)	0(0)	5(100)	0(0)	0(0)	5(>100)	2(4)	0(0)
5	Muscle		Sterile			Sterile			Sterile			Sterile				
5	Heart blood		Sterile													

Numbers outside brackets represent number of positive cultures out of five attempts.
Numbers inside brackets represent mean colony count.

were obtained by the use of tissue grinding methods were not significant under these experimental circumstances. (The loop method is never used for the purposes of bacteriological meat inspection and was included here only for comparative purposes. The German method, on the other hand, is used widely throughout Europe.)

Similarly, 14 days after infection, the German method was shown to be unreliable, but because of the small number of observations there was no conclusive evidence to show which of the remaining methods was the most effective.

There are, however, other factors to consider before selecting methods for further study. In a busy meat laboratory for example, the use of tissue grinders would raise serious practical difficulties, and in no country are they used in routine work. In the case of the Danish techniques, tissue debris remaining smeared over the bottom of the petri dish in the "Danish method II" may make the detection of small, non-haemolytic colonies very difficult. That was no drawback to the method in these experiments, but experience of its routine use has shown that it can cause difficulties.

Table II shows the results obtained in a replicate series of cultures made from rabbit liver by German, Danish I, and tissue grinding methods 7 days after inoculation of the test organism. It is evident that the German method failed to reveal infection more frequently than either of the other two, and that the tissue grinding method had little advantage over the "Danish method I." Presumably all methods failed to demonstrate infection on a number of occasions, and gave widely varying colony counts, because of unequal tissue disruption or uneven distribution of infection throughout the tissue. Bearing in mind the obvious difficulties in standardising these techniques, it is surprising that their coefficients of variation were not greater.

TABLE II

RESULTS OBTAINED BY CULTURING 1 G. "RABBIT I" LIVER BY DIFFERENT TECHNIQUES 7 DAYS AFTER INTRAVENOUS INFECTION

Techniques	Total number of cultures	Number of positive cultures	Range of colony count	Mean colony count	Coefficient of variation
German	20	6	1—6	—	—
Danish I	20	14	3—15	6	76%
Tissue grinding	20	16	3—20	8	73%

TABLE III

A COMPARISON OF THE NUMBER OF POSITIVE CULTURES USING DANISH I PLATING AND SUBCULTURE METHODS 7 DAYS AFTER INTRAVENOUS INFECTION

Tissue	Number of positive plates	Number of positive subcultures from glucose agar
Rabbit I Liver ...	14/20	17/20
Rabbit II Liver ...	14/20	15/20
Rabbit I Muscle ...	0/20	0/20

Table III compares the number of positive cultures which were obtained by the Danish I plating technique, with the number obtained after subculture from tissue remaining embedded in glucose agar tubes. There were no obvious signs of bacterial growth in the tubes at the time of subculture, and it is evident from Table III that for revealing infection, the adoption of the subculture technique formed a useful adjunct to the plating method. Similar proportionate results were obtained when subculture was from tissue in negative blood agar plates.

For a rough estimate of the degree of non-specific infection, therefore, or the mere detection of infection, the use of the "Danish method I" plating technique, with subcultures from tissue embedded in either the glucose or blood agar media whenever plating methods fail, would seem to be more suitable for routine use than any other described here. Moreover, this combined technique has none of the disadvantages associated with the use of fluid media, and it is also a matter of convenience that the glucose medium may be used in routine examination for anaerobes.

Part II

Non-specific Infection in "Normal" Animal Tissue Materials

For the purposes of this work animals were regarded as "normal" when they appeared healthy, had been rested overnight, showed no lesions on *post-mortem* inspection, and their organs and carcase were released *in toto* for human food. The samples, which were collected within 24 hours after slaughter (*i.e.* about the same time they would otherwise have been collected for routine purposes), comprised the following:—

1. ½ to 1 lb. of muscle, covered with fascia, from a fore or hind quarter.
2. A prescapular lymph node, complete in its pad of fat.
3. A whole spleen.
4. ½ to 1 lb. liver, from the portal region.

It was not possible to collect normal kidneys for examination.

The usual precautions were taken during sampling and tissues were handled according to Danish recommendations (Regulations, 1949; Olivant, 1957b).

Methods of Study

Tissue. A large surface area of each sample was sterilised by flaming to charring point, or by the use of a hot iron. Muscle fascia was always left intact. Superficial fat was removed from lymph nodes prior to sterilisation. After aseptic removal of the surface layer, pieces of tissue weighing approximately 1 to 2 g. were removed with a separate set of sterile instruments for cultural examination.

Cultural techniques. Tissue samples were examined by the "Danish method I" described in Part I, and by shake culture in 1 per cent. glucose agar. When either plate or tube techniques failed to reveal evidence of infection after incubation for 24 hours at 37° C., subcultures were made from the tissue remaining embedded in the glucose media to a second series

of blood agar plates. The primary plates and subcultures were then incubated for a further 24 hours. This re-incubation period for primary plates was found to be essential and without it many colonies remained undetected. Control plates were always prepared to check the sterility of the medium. Repeated checks on technique invariably failed to reveal contaminants.

It was generally sufficient to limit identification of cultures to their genus, and in many cases impossible to do more than this.

Results

Results obtained by cultural examination of 100 samples ox muscle, 120 spleens from various species, 100 prescapular lymph nodes from the ox, and 100 samples of ox liver are given in Tables IV and V.

No pathogenic bacteria were isolated from any tissue save pigs' spleens.

Muscle. Bacterial growth (Table IV) was evident in 4 per cent. of primary cultures, in both blood plates and glucose agar tubes, the proportion increasing to 15 per cent. when subcultures were made from tissues embedded in the glucose medium. The results in Table V indicate that the level of infection was very low. None of the streptococcal strains could be typed serologically, and there seemed little purpose in pursuing the identification of micrococci beyond the level of the genus.

Spleen. Spleens were obtained from pigs (51), cattle (47), and sheep (22), and there were no species differences in the proportions infected. Cultures from 2 of the pigs' spleens, found infected by plating methods alone, produced 6 to 10 colonies, the remainder less than 5 (Table V). Each of these 2 pigs' spleens gave a pure culture of *Erysipelothrix rhusiopathiae*, and one other spleen was found infected with this organism after subculture from the glucose medium—again in pure culture. The proportion of spleens found to be infected was increased from 5 per cent. to 26 per cent. by the use of subculture technique.

Lymph node. Twelve per cent. of prescapular nodes were found to be infected on primary culture, 9 by the plating technique, and 3 in shake culture only. Each of the latter gave a mixed growth of clostridia on subculture, two strains of which were non-heat resistant *Cl. welchii*. The colony count on blood plates never exceeded " 5 per sample." The proportion of nodes found infected was increased to 35 per cent. by subculture methods.

Liver. Ninety-five per cent. of ox livers were found infected by the techniques used here, and in 20 per cent. of samples more than 5 colonies developed on blood plates. However, the level of infection never exceeded " 15 colonies per sample." Infections were usually very mixed, but the high proportion of clostridial infections is noteworthy. None of these was associated with heat-resistant *Cl. welchii*. The majority of strains of streptococci grew on bile media, but less than half of those isolated could be classified serologically—and all of these belonged to Lancefield's Group D.

TABLE IV

CULTURAL EXAMINATION OF " NORMAL " TISSUE

Tissue	No. examined	Percentage infected in primary cultures	Percentage infected by "combined" technique	Types of bacteria
Muscle	100	4	15	Non-haem. Strept. (4%) Micrococcus spp. (10%) α-haem. Strept. (4%) Coliform (2%)
Spleen	120	5	26	Non-haem. Strept. (3%) *S. albus* (13%) Clostridia (3%) Coliform (8%) Bacillus spp. (2%) α-haem. Strept. (3%) Erysipelothrix (3/51)
Lymph node	100	12*	35	*S. albus* (8%) Corynebacteria (3%) Bacillus spp. (6%) Clostridia (4%) Non-haem. Strept. (12%) α-haem. Strept. (4%)
Liver	100	60	95	Non-haem. Strept. (58%) Coliform (31%) *S. albus* (8%) α-haem. Strept. (14%) Clostridia (29%)

* In three samples only anaerobic cultures were positive and no growth occurred on blood plates.

TABLE V

THE DEGREE OF INFECTION OF " NORMAL " TISSUE

Tissue	Number of positive plates	Number of positive plates with 5 colonies or less	Number of positive plates with more than 5 colonies
Muscle	4	4	0
Spleen	6	4	2
Lymph node	9	9	0
Liver	60	40	20

Discussion

According to Jepsen (1954) the use of bacteriological methods in *post-mortem* inspection is based on the theory that all tissues, save possibly the liver and kidneys, of healthy and physiologically normal animals are sterile. The evidence in support of this theory is far from clear (Jensen, 1954), and given appropriate cultural methods it is possible that our views on " physiological normality " in slaughter animals may have to be revised.

These experimental results have shown that in a proportion of animals coming to slaughter, bacterial infection is not restricted to reticulo-endothelial tissues; and that in these animals, muscle remains infected with small numbers of organisms which originate from the gut, or any other infected site in the body. Whether one calls such animals " normal " or not is a matter of definition. It is generally accepted that transient bacteraemias must frequently occur during life as the result of physiological stress (Haines, 1937; Legroux & Jéramec, 1944; Dubos, 1955), and it seems reasonable that evidence of bacteraemias should occasionally remain in meat animals and be found at the time of slaughter in intra-muscular lymph nodes, spleens, and livers. It is not known how long such evidence persists in normally functioning R.E. tissue; much must depend on the type of organism and the degree of stress involved. However,

experimental evidence here and elsewhere suggests that when infection is found in muscle, the preceding bacteraemia was very recent—and probably arose during slaughter itself (Jensen, 1954; Keller, 1955). In this work the colony counts from muscle were always less than " 5 per sample," and despite the limitations of the plating technique, indicate a low level of infection. Other workers (Lepovetsky *et al.*, 1953; Cosnett *et al.*, 1956) have drawn attention to the frequency with which a varied bacterial flora is present in muscle and intra-muscular lymph node, the latter suggesting that in the case of superficial lymph nodes, infection *via* skin was not an infrequent route. This suggestion was also made by Adamson (1949) as a result of his experience of human autopsy material.

If these findings are accepted, it becomes essential for the purposes of bacteriological meat inspection, to have some idea of the *degree* and *distribution* of non-specific bacterial infection throughout tissue, so that the meat laboratory may be in a position to advise a meat inspector on appropriate action. It seems unwise, as Albertsen (1956) suggests, to legislate for this in other than the widest terms; nevertheless Danish terminology (Jepsen, 1954) is conveniently emulated, and the following standards are being adopted during a field study of bacteriological meat inspection from this laboratory:—

(a) *Low-grade non-specific infection.* Where infection is found in any or all tissues, and not more than " 9 colonies per sample " are found in muscle, lymph nodes, and spleen by the above plating methods.

(b) *High-grade non-specific infecion.* Where all tissues are more heavily infected than in (a), or where there is clear evidence of recent bacteraemia.

Carcases in group (a) may be released for human food when muscle *p*H values are within the range of normality and organoleptic considerations permit. However, the presence of non-pathogenic Clostridia in lymph nodes has obvious implications for the storage of fresh meat (Cosnett *et al.*, 1956), or the manufacture of " pasteurised " canned products.

Carcases in group (b) require condemnation and frequently originate from moribund, cachectic, or severely injured animals. Muscle *p*H values are usually in the range 6.6 to 7.0

The application of these " standards " is bound to be greatly influenced by the individual's technique and experience; none the less they provide a working basis from which to guide a meat inspector's decision. Provided that full precautions are taken in removing, wrapping, and transporting samples to the laboratory (Regulations, 1949), practical experience has shown that borderline cases are very few, and there is no difficulty in distinguishing the carcase of a seriously stressed animal.

It must be emphasised, however, that the final judgment of a carcase infected with non-specific organisms is always the responsibility of the meat inspector, and only in cases where *specific* infection is found is it possible for a laboratory to send a report firmly recommending condemnation. The plating and subculture techniques described here are

(*Concluded at foot of adjoining column*)

Some Aspects of Nematodirus Disease in Northern Ireland

BY

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SUMMARY.—1. The occurrence of Nematodirus disease in lambs in Northern Ireland is recorded and reference is made to the part played by immature forms of the parasite in causing clinical signs.

2. An outbreak of the disease occurred in susceptible lambs when they were grazing on pastures which had been heavily contaminated with Nematodirus eggs 8 months previously, and were then left unstocked.

Introduction

IN the British Isles Nematodirus disease of lambs has been reported from the Scottish border counties and the N.E. of England (Kingsbury, 1953; Stamp *et al.*, 1955; Thomas & Stevens, 1956). Infection

(*Continued overleaf*)

Studies in Bacteriological Meat Inspection.—*Concluded.*

not primarily designed to reveal infection with pathogenic bacteria, for whose detection reliance is customarily placed upon the use of appropriate selective media.

Acknowledgments.—I wish to thank Professor D. L. Hughes and Dr. A. Buxton for their interest in this work, and Miss Claire O'Rourke for her capable technical assistance.

The plating method (" Danish method I ") was first demonstrated to me by Dyrlaege Merete Lange of the Aarhus Municipal Laboratory, Denmark, by whom it has been used for several years.

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with Nematodirus is widespread in Northern Ireland but clinical Nematodirus disease appears to be confined to the east of the province where, in 1955 and 1956, some 10 outbreaks were observed under circumstances similar to those encountered elsewhere. The rate of stocking tended to be high and the outbreaks occurred in lambs aged 2 to 5 months which were grazing on land that had carried lambs in previous seasons. Two mild outbreaks were seen on hill farms but in both instances the lambs had only newly been moved to the hill from lower land which had been regularly grazed in previous years by ewes and lambs. Otherwise, the condition was seen on lowland farms. Outbreaks occurred from the last week of April onwards. This appears to be earlier than is the case in Scotland or N.E. England (Kingsbury, 1953). The last death to be ascribed to Nematodirus disease was on July 7th. In flocks of from 20 to 150 lambs morbidity rates of from 20 to 75 per cent. were recorded and the mortality rate varied from nil to 20 per cent. This last figure was obtained in an intensively managed flock of 20 lambs. Generally, less than 10 per cent. of the lambs in an affected flock died.

Clinical and *Post-mortem* Findings

The clinical picture of severe scouring, thirst, dehydration and progressive stiffness described by previous writers was observed. In fatal cases death generally occurred about 4 days after the onset of scouring although some lambs were clinically affected for up to 14 days before they died. In those cases illness was severe in the last 3 or 4 days only.

In a small series of 12 *post-mortem* examinations marked lesions were not found. There was a mild catarrh of the small intestine in every case and, in some, changes of the type associated with enterotoxaemia were present. In a number of their cases Thomas and Stevens (1956) showed the presence of terminal clostridial infections.

Helminthological Findings

Estimations were made of the numbers of worms present in the 12 lambs. The results are summarised in Table I.

The other species were Trichostrongylus and Ostertagia spp. In 3 cases more than 4,000 other strongyles were present indicating that the illness may have been due to mixed infestations. However,

TABLE I

	Helminths	Minimum No.	Maximum No.	Average
Small intestine	Nematodirus spp.	6,000	58,000	24,400
	Other species	1,000	12,500	3,200
Abomasum	Other species	300	3,300	1,500

other lambs which died in those flocks had low counts of other strongyles. In general, in addition to the adult worms, extremely large numbers of Nematodirus larvae were found in the intestine and sometimes adult Nematodirus were found in the faeces. In the flock, the history of which is given below, lambs dying 8 and 9 days after removal from the infected grazing to clean land still had many larvae in the intestine. Nematodirus species found were *N. filicollis* and *N. battus*. *N. spathiger* was not observed. The presence of *N. battus* in Northern Ireland has been known since 1953 when Griffiths identified material which Pearson had preserved in 1951 as being an unusual type of Nematodirus. The species was first described by Crofton and Thomas in 1951.

Differential counts were made in 9 cases and from 4 to 82 per cent. of the total Nematodirus present were *N. battus*. It appeared that neither species predominated, but insufficient examinations have been made for this to be regarded as other than a tentative opinion. Kingsbury (1953) and Thomas and Stevens (1956) indicate that *N. battus* may predominate in their area.

A Flock History

Some observations have been made from 1954 to 1956 on a flock where a proportion of the lambs is kept under a highly intensive grazing system. The main part of the flock is managed in the usual non-intensive manner and parasitism is not a problem. In 1954, 30 ewes and 60 lambs were grazed on 4 acres of land fenced off from a field generally used for dairy cattle, but which from time to time had previously carried a few sheep. Routine inspection of the lambs, faecal worm egg counts and *post-mortem* examination of 8 of the lambs in September, 1954, indicated that the lambs had extremely low worm burdens (Pearson, 1954).

In 1955 and 1956 the same area of land was stocked as in 1954. The sheep were in 3 equal groups on equal areas of 1⅓ acres. The layout of the paddocks has been previously described (Baxter & Smyth, 1956). The paddocks were vacant during each winter. In 1955 Nematodirus disease was clinically evident, and in May and June faeces examinations revealed counts of up to 1,600 Nematodirus eggs per gramme. No deaths occurred. The sheep were removed in August, 1955, and the paddocks lay vacant until April 11th, 1956, when they were restocked with lambs and ewes. Signs of nematodiriasis were first seen on May 6th and 10 days later 2 lambs died. The flock was then removed to clean pasture. By May 25th 4 more lambs had died. Thirty-one other lambs exhibited clinical signs of the disease. After mid-June the survivors appeared to make satisfactory progress.

Piperazine adipate was given *per os* on May 16th and 28th. As no untreated control lambs were kept the effect of this treatment could not be distinguished from that of moving the lambs to clean pasture.

No Nematodirus eggs were found in faeces samples from the 60 lambs when they went into the paddocks in April, 1956. One ewe faeces sample contained 120 Nematodirus e.p.g. on this occasion. Subsequently, Nematodirus eggs were not observed in any of the ewes' faeces samples. Sampling was repeated on May 10th and thereafter at intervals. On May 10th egg counts varied from nil to 2,000 e.p.g. but it was not possible to collect samples from some of the

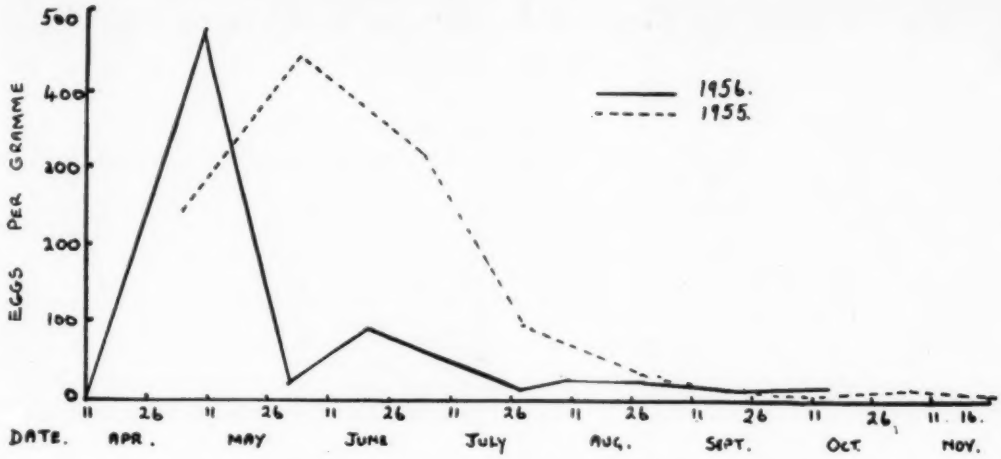

FIG. 1.—Average Nematodirus egg counts in intensively managed lambs.

worst affected lambs. In Fig. 1 average Nematodirus egg counts are shown. A lamb which died on May 18th, 1956, had a count of 3,360 Nematodirus e.p.g. This was the highest count recorded in outbreaks in the area.

In 1955, 36 of the lambs were examined when slaughtered for food and total counts made of the worms present. In 1956 a similar examination was made of all the survivor lambs. The lambs were slaughtered between August and October (1956) or November (1955). The lambs which were clinical cases earlier were fit for slaughter at the same time as the others. Over half of the lambs had rid themselves of Nematodirus by this time and only one lamb was found with more than 3,000 Nematodirus worms. This lamb, slaughtered on August 22nd, 1956, had 10,100 Nematodirus and less than 2,000 other worms. Fewer than 100 Nematodirus e.p.g. of faeces were observed. In May this lamb was clinically affected and 960 Nematodirus e.p.g. were counted then. Eight other lambs with similar or higher Nematodirus egg counts in May and which survived after showing clinical signs, were found to have 1,000 or less Nematodirus worms in the slaughter period.

Discussion

Views vary regarding the source of Nematodirus infection for lambs but there is general agreement that pasture contamination extends from one year to the next. Under some conditions the contamination of the pasture by eggs deposited in the faeces of older lambs and hoggs over the grazing season as a whole has been regarded as being as important as the massive deposition of eggs by lambs in the relatively short period of the year when outbreaks occur (Kingsbury, 1956). Stamp *et al.* (1953) state that the pasture contamination is by the previous year's lamb crop and that autumn grazing by heavily infected hoggs may also occasionally render it unsafe. Thomas and Stevens (1956) have demonstrated, in north-east England, that in a field heavily contaminated by eggs in May and June of one year a larval peak is reached in May of the following year. They refer to the earlier observations of others on the lengthy viability of the larvae.

Circumstantial evidence that the infection may overwinter on the pastures under Northern Ireland conditions, is submitted in the present report. In 1955, in the intensively managed flock described above, ewes and lambs went to the experimental paddocks on April 19th. In May and June the lambs voided many Nematodirus eggs. The ewes and lambs were removed from the paddocks at the end of June and August 24th, 1955, respectively. The paddocks remained unstocked until April 11th, 1956, when ewes and apparently worm-free lambs went on to them. A severe outbreak of Nematodirus disease commenced in the first week of May. Again, only one ewe showed evidence of Nematodirus infestation on one occasion.

It is unlikely that this ewe could have caused the outbreak in the lambs of the group with which she was associated. Infected ewes were not discovered in the two other separately managed groups where nematodiriasis also occurred in the lambs. The carry-over of infection on pasture appears to have been from August, 1955, until April, 1956, a period of 8 months.

The large numbers of larvae, as well as adult worms found in the intestine of the dead lambs, is of interest as Kates and Turner (1953) found in experimental infections that clinical signs often began to appear before Nematodirus eggs appeared in the faeces. This indicated the pathogenicity of the immature parasites. A later experimental study (1955) by the same authors confirmed this view so far as *N. spathiger* was concerned. In Northern Ireland outbreaks, in addition to lambs voiding large numbers of Nematodirus eggs, severely affected lambs were found with faecal counts of 100 to 200 e.p.g. in early May, *i.e.*, presumably before the bulk of the parasites had reached maturity. The opposite circumstance may arise. A lamb which died one month after the commencement of an outbreak in a small

(*Concluded overleaf*)

The Influence of Physical Factors on Dermatomycosis in Domestic Animals

BY

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SUMMARY.—In the dark, at room temperature, arthrospores of T. verrucosum *and* T. equinum *were viable in skin scrapings after 4½ and 4 years respectively, and those of* T. mentagrophytes *and* M. canis *after 1½ years.*

In skin scab 1.5 mm. thick, arthrospores of T. verrucosum *were protected from the action of ultra-violet light equivalent to 437 hours of mid-day, mid-summer, and mid-latitude sunshine.*

Experimentally it was shown that while ultra-violet light was lethal in a few minutes to T. verrucosum *in vitro, hair skin, and lesion scabs individually and collectively protected the dermatophyte. On cattle in Northern Britain the spread of ringworm caused by* T. verrucosum *was not limited by summer sunshine.*

A RECENT survey (McPherson, 1957) has shown that the incidence of *Trichophyton verrucosum* var. among cattle in Northern Britain was almost 3 per cent. of all cattle and that humans quite frequently became infected from this reservoir, as suggested in the report of the Medical Mycology Committee of the Medical Research Council (1956). In that report the importance of animal dermatophytes as a source of infection for man was emphasised. When contemplating control measures the length of time for which the various dermatophytes survive away from a host is of great importance. Walker (1955) found that 25 out of 50 skin scrapings infected with *T. verrucosum* contained viable spores after 15 months' storage in a dry state. The same author and Solomons (1954) recorded circumstantial evidence of the survival of that dermatophyte for 2 years and 1 year 6 months respectively on cattle enclosures. It has long been recognised that ultra-violet light is lethal to fungi on the surface of materials, *e.g.* baking products (Smith, 1946) and there exists a long-standing belief that cattle recover spontaneously from ringworm when put out to grass in spring, due either to better nutrition or the action of ultra-violet light (Rook & Frain-Bell, 1954). Data

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Some Aspects of Nematodirus Disease in Northern Ireland.—*Concluded.*

flock was found to have a total worm burden of 7,000 Nematodirus and 1,000 other strongyles. In the faeces 1,840 Nematodirus eggs and 960 other strongyle eggs per gramme were observed. At this time the other, recovering, lambs had counts of 360 Nematodirus e.p.g. or less. In the absence of immature forms 7,000 Nematodirus worms would not normally be regarded as a dangerous burden. It would be reasonable to assume that whereas the other lambs had acquired an immunity the immune response in this lamb had been insufficient. The high Nematodirus egg count points in that direction as does also the date of death (July 7th). Other deaths which could be attributed to Nematodirus disease, in this and other flocks, were not encountered after mid-June.

Earlier it was noted that clinical cases which recovered were fit for slaughter in the same period of time as their flock mates which were infected but did not exhibit clinical signs. This suggests either that the effects of clinical nematodiriasis were overcome in about 4 months or less or that the other lambs had a somewhat similar retardation in weight gain although they were not obviously ill in May or June. There is need for further investigation of this matter especially in view of Kates and Turner's (1953, 1955) observations that in lambs experimentally infected with *N. spathiger* the retained infections appear to have some slight effect on growth even after the acute phase had passed. Spedding (1955) summarising his work, where Nematodirus was not concerned, came to the conclusion that worm-free lambs showed a significantly greater weight gain than subclinically affected lambs. Spedding cites other authors holding similar views. The relationship of this general proposition to the particular case of mixed Nematodirus infection has yet to be finally elucidated but it is the writer's opinion that, in the field, subclinical Nematodirus infection depresses weight gain (Baxter, 1956).

Acknowledgments.—Thanks are extended to Professor J. Morrison of the Agricultural Research Institute of Northern Ireland, who made the intensively managed flock available for parasitological studies, to Captain A. McLean, City Veterinarian, Belfast, who arranged special facilities for the slaughter of the lambs and to Messrs. D. Greer and S. Rodgers for technical assistance.

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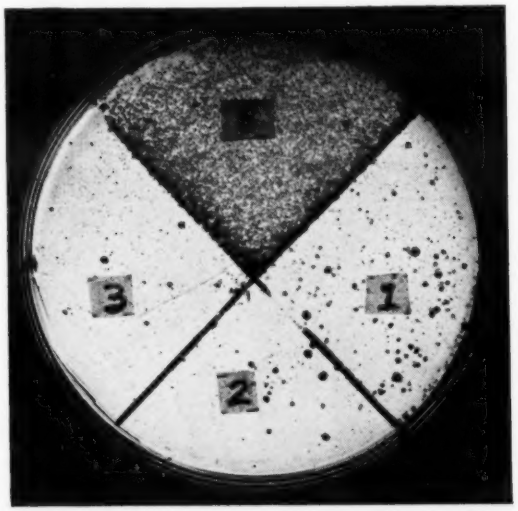

FIG. 2.—The effect of ultra-violet light on *T. verrucosum* (arthrospore suspension). Numerals indicate exposure time in minutes. "S" indicates unexposed sector. Strain "F."

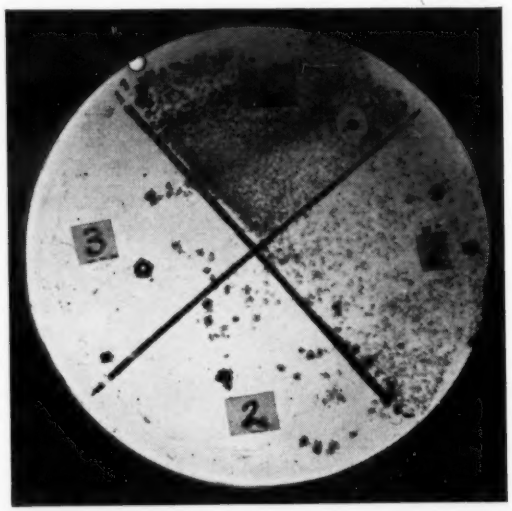

FIG. 3.—The effect of ultra-violet light on *T. verrucosum* (culture suspension). Numerals indicate exposure time in minutes. "C" indicates unexposed sector. Strain "F."

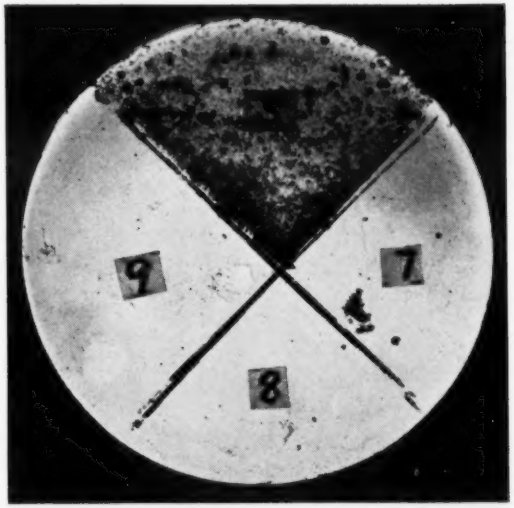

FIG. 4.—The effect of ultra-violet light on *T. verrucosum* (arthrospore suspension). Numerals indicate exposure time in minutes. "S" indicates unexposed sector.

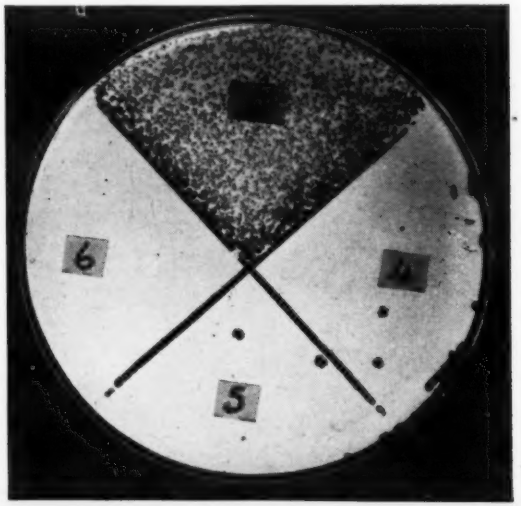

FIG. 5.—The effect of ultra-violet light on *T. verrucosum* (culture suspension). Numerals indicate exposure time in minutes. "C" indicates unexposed sector.

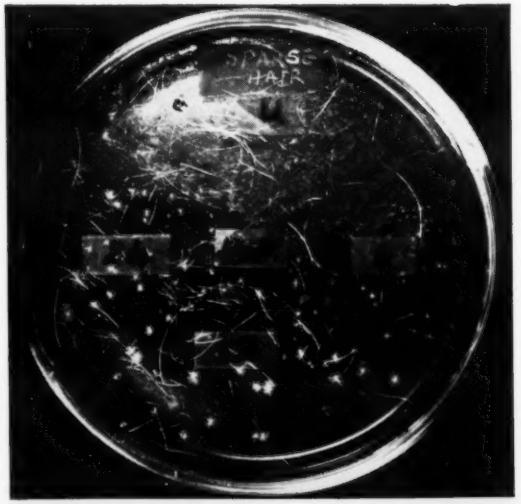

FIG. 6.—Protective action of hair on *T. verrucosum* exposed to ultra-violet light. Numerals indicate time of exposure in minutes. "U" indicates unexposed sector.

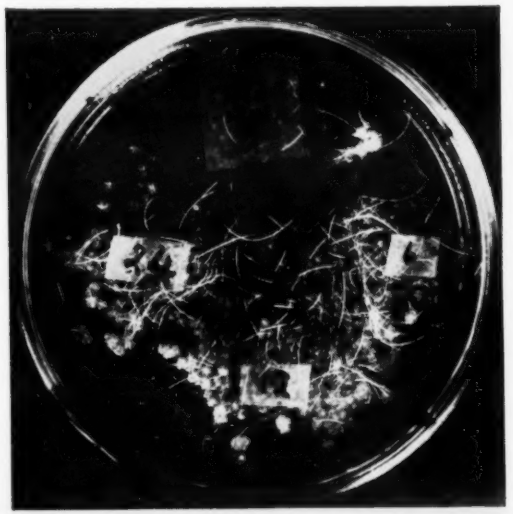

FIG. 7.—Protective action of hair on *T. verrucosum* exposed to ultra-violet light. Numerals indicate time of exposure in minutes. "U" indicates unexposed sector.

obtained by survey (McPherson, 1957), on the other hand, did not show any fall in the incidence of the disease in the summer months. The survival of several dermatophytes stored dry, in the dark, at room temperature, and of *T. verrucosum* when exposed to ultra-violet light in a variety of circumstances are described in this paper.

The Survival of Dermatophytes in Dried Skin Scrapings

Method. From skin scrapings stored dry in cardboard boxes at laboratory temperature, cultures were made on nutrient agar (Austwick, 1954) at 37° C. for the *Trichophyton* spp. and on Sabouraud's glucose agar at room temperature for *Microsporum canis*.

Results. These are shown in Fig. 1.

All samples of *T. verrucosum* material and 2 of 3 *T. equinum* specimens were still viable when last tested, the oldest samples of each having survived for over 4 years. The other dermatophytes died out within the period of investigation. The longest survival recorded for *M. canis* and for *T. mentagrophytes* was 1½ years. In the recoveries of *T. verrucosum* and *T. equinum* after 2½ years' storage the viable spores were less numerous but colonies could still be readily obtained by the routine method.

Infectivity of Stored Material for Cattle

Two samples of *T. verrucosum* (B.166a and E.678) after 3 years 5 months' and 2 years 5 months' storage respectively proved capable of infecting a 2-year-old Jersey heifer when rubbed into scarified skin. The lesions, which first became visible on the 17th day, conformed to the description recorded by Hoerlein (1945).

The Survival of *T. verrucosum* when Exposed to Ultra-violet Light

All exposures were at 24 inches from the tube of a Model II Hanovia lamp. At that distance the irradiation was about 720 micro-watts per cm². One minute and 45 seconds' exposure was equivalent to 20 minutes of mid-day, mid-summer, mid-latitude sunshine, and produced on normal human skin a minimum of erythema (Hanovia, Ltd., 1955).

Effect of Exposing Arthrospores and Cultures of *T. verrucosum* to Ultra-violet Light

Materials

Arthrospores. From a yearling heifer (Case F) skin scabs, which were heavily laden with arthrospores, and contained no contaminant fungi and very few bacteria, were obtained. No other suitable supply of arthrospores was available for experiment.

Culture Suspensions. A 10-day culture on nutrient agar (Austwick, 1954) of the same strain "F" provided chlamydospores, mixed with hyphae. Ten-day-old cultures of a further 5 strains of *T. verrucosum* were also tested, *viz.* C.516, E.678, E.803, E.904, and E.920.

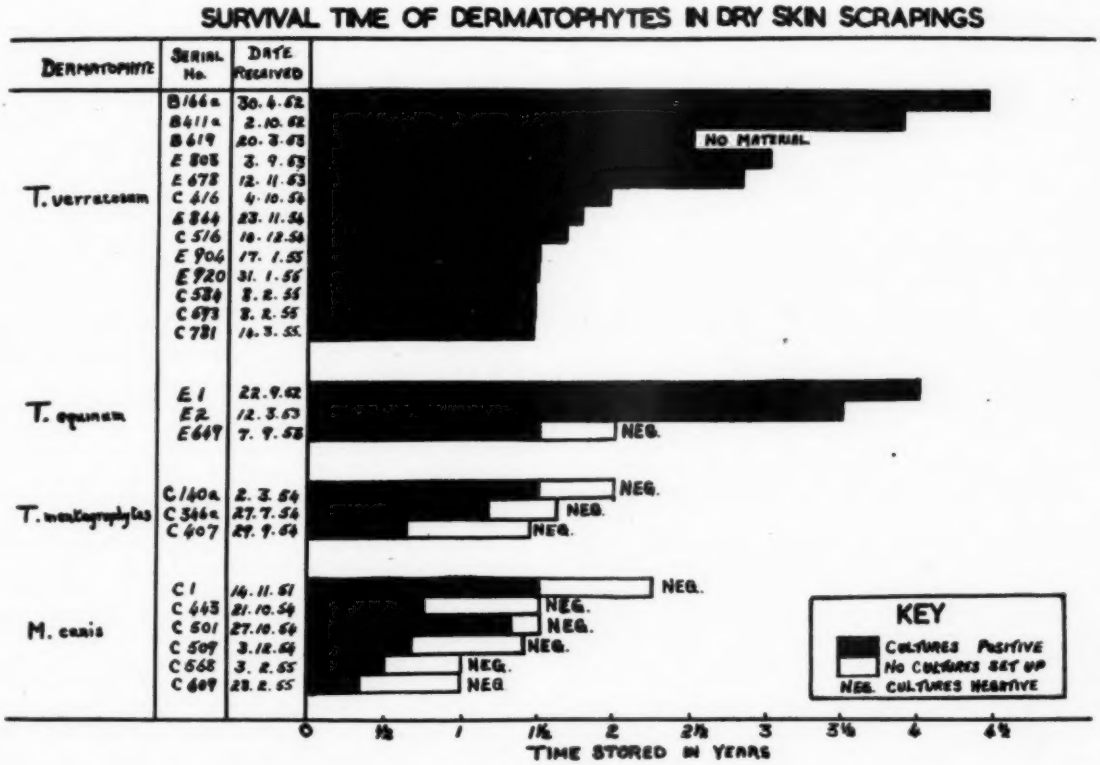

FIG. 1.

Methods

The skin crust and the colonies removed from the medium were each reduced to a fine suspension in sterile distilled water by use of a Griffith tube. The spores were counted using a haemocytometer, and each suspension was adjusted to contain approximately 300,000,000 spores per ml. From each, nutrient agar antibiotic treated plates (Austwick, 1954) were surface sown by Pasteur pipette with an excess of suspension. After removing the excess by pipette the surface moisture was dried off in the incubator. The glass petri dish lids were then replaced by aluminium lids which had been cut into quadrants. Each minute an additional quadrant was removed until a series of exposures of up to 15 minutes had been made, with one-quarter of each plate left unexposed as a control. The glass lids were then replaced and the plates were incubated for 10 days at 37° C. in a moist atmosphere, the whole experiment being in triplicate.

Results

The results are recorded in Table I and illustrated in Figs. 2 to 5 inclusive.

TABLE I

Strain	Mean Minimum Time to Kill all Spores	
	Culture spores (Chlamydospores)	Skin scab suspension (Arthrospores)
F	6·0 minutes	7·6 minutes
C516	6·3 ,,	—
E678	5·0 ,,	—
E803	6·0 ,,	—
E904	5·3 ,,	—
E920	6·0 ,,	—

The plates S and C (Figs. 2 to 5) were sown with arthrospore and culture suspension respectively, both being Strain " F." The effect of the ultra-violet light was evident after only 1 minute's exposure. After 3 minutes' exposure only odd colonies appeared in both series, but were more persistent in the case of the skin scab material which was more difficult to reduce to a fine suspension. In Fig. 4 a multiple colony appeared despite 7 minutes' exposure, suggesting a thick piece of a material. After 15 minutes' irradiation, plates sown with a coarse suspension still contained viable spores.

Protective Action of Bovine Hair and Skin Crust on Arthrospores Exposed to Ultra-violet Light

(a) *Hair*

Materials. The same arthrospore suspension " F " as in the previous experiments was used. White bovine hair was sterilised in universal containers.

Method. Plates were prepared as above, but before exposing them to ultra-violet light, the hair was placed on the surface of the medium. The plates designated " thick " hair in the figures had a hair covering commensurate with the normal bovine coat.

Results. The Figs. 6 and 7 illustrate the results. Under the thick covering of hair, spores were still viable after 220 minutes' exposure, though the colonies were small, smooth, and cream-coloured. The control quarter on which no hair had been placed failed to show growth. All 3 of the triplicate plates showed this feature and investigation showed that during long exposures sufficient light rays were deflected, *via* the under surface of the aluminium cover of the control quadrant, to partially illuminate the area and eliminate all viable spores. When black hair was employed and the control section was also covered with hair, no such lethal action took place on the control quadrant.

(b) *Scab from a Bovine Lesion*

Method. A scab 15 × 6 × 1.5 mm. (Strain " F ") was exposed, outer side uppermost, in a petri dish on a dark surface. Cultures were made from small pieces of the scab removed at intervals during the exposure, which extended over 12 days.

Results. These are shown in Table II.

TABLE II

PROTECTIVE ACTION OF SCAB FROM A BOVINE LESION ON *T. discoides* ARTHROSPORES

Times during Exposure of Scab to Ultra-violet Light at which Cultures were made. (Minutes)									
70	170	325	600	820	875	950	1,630	2,295	2,445
Result of Cultures									
+	+	+	+	+	+	+	+	+	—

+ = Growth obtained ; — = No growth obtained.
2,295 minutes' exposure to ultra-violet light = 437 hours' exposure to mid-day, mid-latitude, mid-summer sunshine. Average Summer sunshine May-August (inclusive) during 1954, 55 and 56 was 624 hours.

After 2,295 minutes, colonies were smooth, cream-coloured, and compact, as occurred after 220 minutes in the previous experiment with hair; nevertheless, a profuse growth occurred. The scab was inverted for the next exposure (150 minutes) after which no further growth could be obtained, indicating that the last surviving spores had been relatively easily reached from the under surface of the crust.

Survival of *T. verrucosum* in Lesions on the Relatively Hairless Skin of Human Cases Exposed to Ultra-violet Light

The effect of exposing natural lesions due to *T. discoides* on 8 adult humans to ultra-violet light was studied. The exposure time varied considerably, but in general it was observed that elimination of the dermatophyte was most quickly achieved when a local " sunburn " was produced. One case was of particular interest in that failure to produce erythema coincided with failure to eliminate the dermatophyte. This young man had a recent lesion on his wrist, some 10 mm. in diameter, which was exposed to ultra-violet light for 5 minutes daily for 3 days. No erythema occurred but the lesion subsided temporarily. Eleven days after ceasing treatment the lesion was 25 mm. in diameter, very active, but without a thick crust. Seventy-five minutes' exposure was given over 7 days. No erythema resulted, in spite of the fact that the area had been kept covered with

a bandage for 14 days prior to this treatment, and an initial exposure of 7 minutes was made. The lesion dried, became slightly scaly, and of nearly normal colour. Six days after the last exposure an active lesion of 35 mm. diameter, from which *T. verrucosum* was isolated, was present.

Effect of Exposure of Infected Cattle to the Ultra-violet Light of Summer Sunshine

In August, 1953, all of 41 calves at grass since the previous April in a field without shelter from the sun were found affected with *T. verrucosum*. In 1955 a group of 24 calves on the same field were all affected by August 1st, despite 668 hours of sunshine in the previous 3 months. In the latter group, disease was present on a few animals when they were put to grass on May 1st. By July 1st, 12 had visible lesions, and by July 31st, all had visible lesions.

Conclusions

The survival of *T. verrucosum* and *T. equinum* for over 4 years in a dried state, in the dark, at room temperature, and of *T. verrucosum* in a thin skin scab subjected to long periods of ultra-violet irradiation, demonstrated the importance of infected premises as a reservoir for these dermatophytes. From the public health viewpoint the survival for over a year of *T. mentagrophytes* and *M. canis*, chiefly found on dogs, cats, and man in this country, is important. La Touche (1956) considered that the major factor in contraction of ringworm by man from cats was "the opportunity of contact with infected animals," to which might be added "or materials contaminated by them."

The experiments with ultra-violet light have shown that though *T. verrucosum* is very susceptible to the lethal action of these rays, such action is easily impeded or prevented. A relatively thin piece of skin scab (1.5 mm.) from a bovine lesion gave protection from the equivalent of 437 hours of mid-day, mid-summer, mid-latitude sunlight. Near Edinburgh the average summer sunshine, May to August inclusive, for the years 1954, 1955, and 1956, was 624 hours, including weak morning and evening light and sunshine on hazy days. It is concluded that *T. verrucosum* shielded by scabs or other protective material will survive even in sunny situations throughout the summer in Northern Britain.

Bovine hair, equivalent to the normal coat of a white animal, protected *T. verrucosum* from the action of ultra-violet light for the equivalent of 42 hours of continuous strong sunlight of an intensity described above, and it was demonstrated that, provided marked inflammation and exfoliation is not produced, the comparatively hairless thin human skin (and presumably animal skin) affords *T. verrucosum* in the depths of the epidermis considerable protection from ultra-violet light. In addition to protecting fungal elements within itself, a scab doubtless protects the dermatophyte in the skin beneath for an even longer period. The combined action of hair, skin, and skin scabs presumably minimises any direct beneficial result which might be expected from exposing infected cattle to the ultra-violet rays of summer sunshine. The history of the 2 groups of cattle here reported, especially that of the 1955 group, illustrates the correctness of this assessment. The latter year was noted for long daily periods of bright sunshine. Summer outbreaks of ringworm in cattle at grass have been recorded by Ainsworth and Austwick (1955), observed by Staugaard (1954) in Denmark, and were encountered during a recent Survey (McPherson, 1957). From all this evidence it is apparent that summer sunshine does not influence the spread of *T. verrucosum* infection on cattle in Northern Britain.

Summary

In the dark, at room temperature, arthrospores of *T. verrucosum* and *T. equinum* were viable in skin scrapings after 4½ and 4 years respectively, and those of *T. mentagrophytes* and *M. canis* after 1½ years.

In skin scab 1.5 mm. thick, arthrospores of *T. verrucosum* were protected from the action of ultra-violet light equivalent to 437 hours of mid-day, mid-summer, and mid-latitude sunshine.

Experimentally it was shown that while ultra-violet light was lethal in a few minutes to *T. verrucosum in vitro*, hair skin, and lesion scabs individually and collectively protected the dermatophyte. On cattle in Northern Britain the spread of ringworm caused by *T. verrucosum* was not limited by summer sunshine.

Acknowledgments.—I wish to thank Professor G. F. Boddie for facilities to carry out this work, and Mr. R. S. Hood, F.I.B.P., F.I.S.T., for the preparation of the photographs.

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ARTICLES OF ASSOCIATION OF THE B.V.A.

Following a recommendation by the Finance sub-committee, a number of copies of the B.V.A. Articles of Association Standing Orders and Bye-laws have been printed for the use of members. Members of Council are invited to apply to the General Secretary for copies, which will be sent to them free of charge. Other members of the B.V.A. who apply for copies will be asked to pay a nominal sum of one shilling plus threepence postage.

THE NORTH OF IRELAND DIVISION GOLDEN JUBILEE DINNER

The golden jubilee dinner of the North of Ireland Veterinary Association was held at the Woodbourne House Hotel on October 8th. The Association's President, Dr. Luke, was in the chair, and the guest of honour was the Prime Minister of Northern Ireland, Lord Brookeborough. Other distinguished guests, among the company of over 100 who sat down to dine, were Mr. J. M. Ingram, President of the B.V.A., Mr. G. N. Gould, President of the R.C.V.S., Professor Mitchell, an honorary member of the N.I.V.A., the Lord Mayor of Belfast, Mr. J. N. Ritchie, The Rev. Robert Moore, Minister of Agriculture, Mr. W. G. R. Oates, and Professor Baskett, Dean of the Faculty of Agriculture, Queen's University. To the general regret, Professor Lamont was prevented from being present by illness.

In proposing the toast of the profession, Lord Brookeborough spoke of the tremendous increase in the value of the output of Ulster farms, which now stood at about £100,000,000 per year, about 80 per cent. of which came from livestock and livestock products.

As efficiency in agricultural methods grew, so the problems facing the veterinary profession grew. There were some 200 veterinary officers attached to the Ministry of Agriculture, which represented the Government's appreciation of the good work the profession could do, and was doing.

"As the standard of living rises in Northern Ireland, your problems will not diminish, but increase," the Prime Minister declared, "but I am certain you will continue to help us make those who make their living from the land a happier, more contented, and wealthier people."

In responding, Mr. Gould said:—

"You have referred, Mr. Prime Minister, to the outstanding contribution made by agriculture to the trade and prosperity of Northern Ireland. I do not think it is generally appreciated how great was the contribution of the agricultural industry of these islands to our war-time survival and since that time to our economic salvation when assailed by problems which many of us do not pretend to understand but are very much aware of. This somewhat resembles the lack of appreciation which appeared to be accorded to veterinary science, particularly before the war, by many in government, in ancillary sciences, in the industry, and by the public.

"I would emphasise the continuing need for Government, for the industry and the people of these islands, to ensure the health of the veterinary profession of the future by adequate provision for veterinary education, for research, for State medicine, and last, but not least, for the encouragement of the practising veterinary surgeon.

"Recently it has been our privilege to co-operate in the problem of meat inspection in your bacon factories—to provide for the training, examination, and registration of meat detention officers working under veterinary supervisors. The proposed system resembles that which has been in existence in Scotland for many years. I understand that one side of bacon in every four sold in England is produced in Northern Ireland.

"It cannot be too clearly stated that not only has the veterinary profession a great interest in meat inspection from the public health angle—an interest actually shared and participated in, in all the more advanced countries in the world—but the indications are that the progress in disease control is fast approaching the point when the problems to be faced will be the less spectacular and the more insidious diseases, where statistical and other information requisite for a practical control policy is readily available in the slaughter-houses."

The North of Ireland Veterinary Association was proposed by Mr. Ingram. In the course of his speech Mr. Ingram said:—

"It is widely recognised, Mr. Prime Minister, that your veterinary experts are men of the widest practical knowledge and good sense. Your flourishing agricul-

Mr. J. M. Ingram, President of the B.V.A., is seen with Dr. J. K. L. Pearson, Secretary of the North of Ireland Veterinary Association.

ture is substantially in their debt, and in the debt of those other members who are in private practice. Agricultural communities, not only in your own country but in very many others, have reason to be grateful in particular for the research veterinary surgeons have fostered and the practical knowledge they have acquired of that uncommonly useful and previously much neglected animal—the pig. As we all know, the economic importance of the pig industry has grown enormously and continues to do so. There is no reason why that industry, within the British Isles, should not be in every way equal in efficiency and production cost to that of Scandinavia. Indeed, between the enthusiasm of your veterinarians and the willingness of pig farmers to co-operate with them, I should say that state of affairs is well on the way.

"The field of work of the veterinary surgeon is for ever widening, and there are still services he could

render to the community and to the farmer, both in a practical and an advisory capacity, were he invited to do so. It is in this connexion that I acknowledge the work members of your Association have done in the investigation of animal housing and general hygiene. The old notion that we are the people to be called in only in time of sickness or injury on the farm is passing. Our rôle in preventive medicine, in animal hygiene, and in dietetics is growing fast, as it should do; and there are many round this table to-night who have made, and who continue to make, important contributions to these subjects."

The toast of The Guests was proposed by Dr. W. R. Kerr deputising for Professor Lamont. Mr. J. N. Ritchie, the Chief Veterinary Officer, and Mr. Ian Fraser, a local member, replied.

DIAMOND JUBILEE OF THE VICTORIA VETERINARY BENEVOLENT FUND

The following communication has been received from the President of the Fund:—

The Victoria Veterinary Benevolent Fund was founded in 1897 to commemorate the Diamond Jubilee of Her late Majesty, Queen Victoria. This year, being the Diamond Jubilee of the Fund, its Council wishes to take the opportunity afforded by the occasion to make a special appeal to all members of the profession, especially those who, at the moment, do not assist the Fund. They are asked to re-examine the question and, if they possibly can, to give each year a little, or a little more, as may be appropriate. The Council feel that if the character of the work carried out by the Fund were more generally realised, much greater support would be forthcoming.

The Fund has many loyal and devoted friends but, at the present time, the number of subscribing members is less than one-fifteenth of those whose names are on the Register. The total amount received in 1956, in subscriptions, was £385. Thanks, however, to the splendid help of the Ladies' Guild, whose members work unsparingly for the Fund, and whose efforts are beyond all praise, the subscription account was increased to £1,340. Our total expenditure on relief for the same period was £2,715, the difference being made up out of income from investments. This sum was distributed among 9 members of the profession, 19 widows (16 being between the ages of 60 and 80), 10 daughters of deceased members, and 4 recipients with young children, the grants being earmarked for the children's education. This latter aspect of the work of the Fund is of the greatest importance, since it means that, where a deceased veterinary surgeon leaves young children, their education is very largely looked after by grants in aid.

It is surely a sacred duty, which falls upon us all, to do what we can for our less fortunate brethren, and we ask for your help in order that we may be able to assist these cases to a greater extent. The minimum subscription for membership is 10s. 6d. per annum and the Council earnestly ask for your support to this Appeal. The Secretary will be most happy to send to any member a bankers' order form or, of course, a form of deed of covenant for those members who are prepared to support the Fund for a minimum period of 7 years, thus enabling the Fund to recover tax.

Alternatively, if members of the profession would like to help by taking a collecting box for their surgeries, will they please contact the secretary, who will gladly send a box by return of post.

It is not given to us to know, or forecast, what the future may hold; the work of a veterinary surgeon is hazardous and, as in all walks of life, good health is a prerequisite to success. Will you, therefore, help us to assist those who cannot help themselves by reason of circumstances over which they have had no control?

H. W. DAWES,
President.

10, Red Lion Square,
London, W.C.1.

Current Literature

ABSTRACT

Experimental Studies Relative to the Therapeutic Use of Ultrasound. HERRICK JONES *et al.* *J.A.V.M.A.* **128.** Pp. 571-7.

Ultrasound, like audible sound, is vibratory mechanical energy. In view of the publicity given to ultrasonic therapy in the treatment of malignant processes the authors studied its mechanics, technique, dosages, potentialities, and hazards.

A graph of the cross-section of the radiation field pattern of the usual ultrasonic generator shows it to be acutely conical and indicates the necessity for great accuracy in directing the maximum energy towards the site to be irradiated. Proper coupling of ultrasonic energy to tissue is most important, and this requires an appreciation of a parameter known as " acoustic impedance," since maximum ultrasonic energy is only transferred from one medium to another when the acoustic impedances of the 2 media are the same. That of muscle is approximately equal to that of water (and mineral oil is a satisfactory coupling agent), whereas ultrasound cannot be transmitted through air without great loss of energy: consequently air can be used as a shield against possible injury during irradiation.

By reason of the almost 100 per cent. reflection of energy at the intestinal tissue-air interface it is possible to produce ultrasonic burns of the intestinal mucosa and since the soft-tissue-bone interface is also mismatched the result of 3 successive exposures of 5 minutes' duration to an ultrasonic generator of 20 watts at a frequency of 800 kc. per second was to produce fracture of the femur of a dog 15 days after exposure.

The authors conclude that the analgesic effects claimed for ultrasonic therapy are overrated, that its heating effect, though potentially dangerous, can be controlled, and that its non-thermal action in degassing tissue is extremely destructive. But ultrasound may be useful for certain biological measurements and may in time become a valuable diagnostic agent.

J. P.

News and Comment

MINISTRY SCIENTIST TO VISIT AUSTRALIA

An award under the Royal Society and Nuffield Foundation Commonwealth bursaries scheme has been made to Mr. H. V. Thompson, Principal Scientific Officer, Infestation Control Division, Ministry of Agriculture, Fisheries and Food.

The purpose is to assist him to visit Australia to study myxomatosis as it affects the rabbit population and indirectly as it affects predators and agriculture in general.

Mr. Thompson, who will also visit New Zealand to obtain first-hand information on the methods used against rabbits in that country, left this country on Saturday, October 19th, and will be away until June next year.

UNIVERSITY NEWS

Bristol

The new session began on October 3rd. Of the 123 veterinary students, 26 are freshers. New appointments to the staff include Mr. A. T. H. Batten, B.V.SC., M.R.C.V.S., Junior Fellow in Veterinary Surgery; Mr. N. St. G. Hyslop, B.V.SC., M.R.C.V.S., D.T.V.M., Lecturer in Clinical Pathology (Veterinary); and Miss Barbara Q. Weaver, M.R.C.V.S., Lecturer in Veterinary Surgery.

Professor C. S. G. Grunsell will deliver his Inaugural Lecture on November 29th. His subject will be "The Growth of the Discipline of Medicine in Veterinary Science." Admission is free, by ticket obtainable from the Registrar of the University.

Liverpool

Professor D. L. Hughes, F.R.C.V.S., DIP.BACT., Professor of Veterinary Pathology, delivered his Public Inaugural Lecture entitled "Man and his Animals" on Thursday, October 17th, in the Arts Theatre of the University.

R.C.V.S. OBITUARY

We record with regret the death of the following member of the profession:—

SCOTT, William Morgan, DR.MED.VET. (ZURICH), F.R.C.V.S., F.R.S.E., Fryern Hall, Bridgwater, Somerset. Qualified May 23rd, 1894, at the Royal (Dick) Veterinary College, Edinburgh. Died October 11th, 1957, aged 87 years.

PERSONAL

Births

MACALLISTER.—On October 16th, 1957, at Clenoch Hospital, Stranraer, to Fay (*née* McWilliam), wife of Donald I. MacAllister, M.R.C.V.S., D.V.S.M., Broadstone House, Stranraer, a daughter, sister to Robin, Jane, and James.

PHILLIPS.—On October 3rd, 1957, to Maureen (*née* Hannan), wife of John G. Phillips, M.R.C.V.S., 19a, Friars Road, Coventry, Warwickshire, a daughter, Judith Anne.

ROBERTS.—On October 9th, 1957, to Dorothy, wife of H. Gerald Roberts, M.R.C.V.S., of "Taronga," Grove Hill Crescent, Falmouth, Cornwall, a son, Brian Clive, brother for Sandra and Ian.

Marriage

GRAHAM—SANGSTER.—On October 5th, 1957, at Lochmaben Church, Neil, younger son of Mr. and Mrs. Joseph Graham, Hillend, Annan, to Winifred Margaret, eldest daughter of Mr. G. A. Sangster, M.R.C.V.S., and Mrs. Sangster, Mayfield, Lochmaben, Lockerbie.

Mr. J. R. Knowles, Senior Veterinary Officer, Northern Nigeria, is promoted Principal Veterinary Officer, Northern Nigeria.

COMING EVENTS

October

31st (Thurs.). Meeting of the East Midlands Division at the Royal Hotel, Ashby de la Zouch, 2.30 p.m.

November

1st (Fri.). Annual Dinner Dance of the North Wales Division at the Imperial Hotel, Llandudno.
Autumn Meeting of the Eastern Counties Veterinary Society at the School of Veterinary Medicine, Madingley Road, Cambridge, 10.30 a.m.
Meeting of the Lincolnshire and District Division at the Eastgate Court Hotel, Lincoln, 2.15 p.m.
Meeting of the Lancashire Veterinary Association at the Grand Hotel, Aytoun Street, Manchester, 3 p.m. Cocktails and informal dinner at the Café Royal, Peter Street, Manchester, 7 p.m.

6th (Wed.). Meeting of the Midland Counties Division at the Regent Hotel, Leamington Spa, 2.30 p.m.

7th (Thurs.). General Meeting of the Central Veterinary Society at the Royal Veterinary College, Camden Town, N.W.1, 5.30 p.m.

8th (Fri.). R.V.C. Students' Union Commemoration Ball, 8 p.m. to 2 a.m.

14th (Thurs.). Annual Dinner and Dance of the Victoria Veterinary Benevolent Fund in the Northern Hotel, Aberdeen, 7.30 p.m.

18th (Mon.). 8th Annual Dinner of the University of Bristol Centaur Society at the Berkeley, Bristol.

27th (Wed.). Southern Counties Veterinary Society and N.A.A.S. Joint Grassland Symposium at the Royal Hotel, Winchester, 8.15 p.m.

29th (Fri.). Golden Jubilee Dance of the North of Ireland Veterinary Association at the Grand Central Hotel.

BRITISH VETERINARY ASSOCIATION QUARTERLY MEETINGS IN LONDON

Wednesday, November 13th, at No. 7, Mansfield Street.

10.30 a.m. Small-Animals Committee.
2.00 p.m. Parliamentary and Public Relations Committee.
4.00 p.m. Home Appointments Committee.

Thursday, November 14th, at No. 7 Mansfield Street.

10.00 a.m. Veterinary State Medicine Committee.
11.30 a.m. Farm Livestock Committee.
12 noon Finance Sub-Committee.
2.15 p.m. General Purposes and Finance Committee.

Friday, November 15th, at the Connaught Rooms—
10.30 a.m. Meeting of Council.

THE VICTORIA VETERINARY BENEVOLENT FUND

The Annual Dance of the County of Ayr Ladies Guild will be held in Western House, Ayr, on Thursday, November 21st. Tickets, price one guinea, may be obtained from Mrs. A. L. Wilson, 31, Ashgrove Street, Ayr (Telephone: Ayr 65757).

ADDRESSES OF DISEASE INFECTED PREMISES

The list given below indicates, first the county in which are situated the premises on which disease has been confirmed, followed by the postal address and date of outbreak.

Anthrax

Northants. Kings Meadow, Kings Lane, Higham Ferrers, Wellingborough (Oct. 17).
Pembs. Robleston, Camrose (Oct. 15).
Somerset. Shawford Farm, Beckington, Bath (Oct. 14).

Atrophic Rhinitis

Glos. Upham House, Dymock (Oct. 15).

Fowl Pest

Essex. Ashby, Lodge Lane, Collier Row, Romford (Oct. 15).
Lancs. Hazeldene, Station Road, Little Hoole, Preston; 130, Moor Lower Road, Croston, Preston (Oct. 14); Critchleys Farm, Liverpool Old Road, Much Hoole, Preston; Westfield, Moss Lane, Little Hoole, Preston; Gabbots Farm, Moss House Lane, Much Hoole, Preston; Meadowside, Ratten Lane, Hutton, Preston; Niscon, Hillock Farm, Runshaw Moor, Euxton, Chorley (Oct. 15); Lachine House, Ratten Lane, Hutton, Preston; Hazeldene, Sheephill Lane, New Longton, Preston; Smithy Lane Farm, Smithy Lane, Much Hoole, Preston (Oct. 17); Corges Farm, Fourgates, West Houghton, Bolton; Bury Farm, Sandy Lane, Brindle, Chorley; 5, Peartree Road, Croston, Preston (Oct. 19); 149, Liverpool Road, Penwortham, Preston; Excelsior Farm, Dawkers Lane, Euxton, Chorley (Oct. 20).
Leics. The Piggeries, Central Street, Countesthorpe (Oct. 18).
Lincs. The Vicarage, Edlington, Horncastle (Oct. 15); Masterdyke, Sutton St. James, Spalding (Oct. 17); Broadgate Road, Sutton St. Edmunds, Spalding (Oct. 19); Willow Tree Farm, Deeping St. Nicholas, Spalding (Oct. 20).
Suffolk. Sycamore Farm, Kenton, Stowmarket (Oct. 20).

Swine Fever

Essex. Floradene, Lodge Lane, Collier Row, Romford (Oct. 21).
Hereford. Rowley Cottage, Hamnish, Leominster (Oct. 21).
Lancs. Little Middop Farm, Middop, Gisburn, Clitheroe; Lower Kilshaw, Carleton, Blackpool (Oct. 17).
Leics. Saxelby, Melton Mowbray; 80, Saxby Road, Melton Mowbray (Oct. 17); The Piggeries, Central Street, Countesthorpe (Oct. 18).
Lincs. Haltoft End, Freiston, Boston (Oct. 18).
Norfolk. Bridge Farm, Antingham, North Walsham (Oct. 14); Lime Kiln Farm, Barton Turf, Norwich; Newlands Nursery, Stalham, Norwich (Oct. 21).
Oxford. The Haven, Carterton (Oct. 18).
Somerset. South Wood Common Farm, Evercreech, Shepton Mallet (Oct. 21); Bathford Gardens, Box Road, Bathford, Bath (Oct. 18).
Sussex. Akehurst Farm, Copthorne, Crawley (Oct. 21).
Warwicks. Moat Farm, Kilsby, Rugby (Oct. 14); Dairy Farm, Claybrooke Magna, Rugby (Oct. 15).
Wilts. Stills Farm, Bromham, Chippenham (Oct. 21).
Yorks. Old Trent Road, Beckingham, Doncaster; Carr Lodge Farm, Balby, Doncaster (Oct. 14); Healaugh Grange, Healaugh, Tadcaster (Oct. 21).

CORRESPONDENCE

The views expressed in letters addressed to the Editor represent the personal opinions of the writer only and their publication does not imply endorsement by the B.V.A.

The "Rights" of Animals

Sir,—Having read Mr. Bongard's eulogy on mankind, I feel that he must indeed be lucky in his associations with his fellows, or perhaps he is a hermit and reads no newspapers save THE VETERINARY RECORD. The human race appears to me, generally speaking, if not an accident, to be at least pretty nasty, our own nation perhaps a little less so than most.

Major Wilkins has pointed out a question, the answer to which must settle most of this discussion regarding the " rights " of animals: " Do animals possess souls?" Although a Christian, and despite this idea being quite contrary to the teaching of the church, I have always been convinced that they both do, and by all logic, must. If we accept that in common with other animal life man evolved over vast periods of time from simple elementary forms of life, at what stage in this evolution did he acquire an immortal soul, and why must it be assumed that other animal life did not do likewise? I prefer to consider the soul as the essence of life present in all living creatures in a degree varying with their mental and anatomical development, and I cannot agree that this should be prolonged after death only in one species.

I should have thought that any intelligent person spending his life working amongst animals would appreciate that there really is not all that difference between the mental processes and anatomical structure of man and those of the more highly developed members of the animal population. I would recommend Mr. Bongard to look into the eyes of his next patient and then into the eyes of its owner, and reconsider his dogmatic statement concerning after life.

Yours faithfully,
L. W. FULLER.

Braeside,
Dulverton,
Somerset.
October 20th, 1957.

Sir,—I was very impressed by Mr. Thornton's reply in THE VETERINARY RECORD of October 19th, 1957. This correspondence on the rights of animals (and, Sir, I think " rights " without inverted commas on this side of the house is more appropriate) must be producing an annoying impatience amongst the more practical members of the profession. I crave your indulgence in once more entering this perilous arena.

No philosopher, not even so scholarly a businessman as Mr. Thornton with his enviable erudition, is in possession of the truth. " Obedience potentiality," as he so clearly puts it, must begin by accepting *something* as true; I agree. The limit of this " obedience," however, is surely the recognition through independent thinking of our *convictions* being true.

Plato's *Myths* exemplifies the idea " as being is to becoming, so truth is to faith." The strongest

philosophical impulses to-day for the Christian who philosophises emanate from Plato who argued that we can have no certain knowledge of the Creation. Animals, he considered, were merely deteriorated humanity while diseases sprang from the disturbance of bodily elements. What do we think to-day in 1957? Dr. Michael Ramsey, Archbishop of York, writing in *The Sunday Times* of October 20th, says " as the potentiality of animal life is seen in the remarkable animal called man, so the potentiality of man is seen in Him whom the New Testament calls ' the New Man,' Christ." To me there is some vague similarity in this, and animals are surely in the " order of battle," in the hierarchy of life? *Amicus Plato, magis amica veritas.*

Lack of faith may not be more than a fruitful product of enlightenment. True enlightenment, however, only clarifies prejudices, and science is one of its main elements. " Modern " science, however, is apt to deny the dignity of man and animals, and this ultimately must lead to philosophical suicide.

Philosophy and existence cannot be reduced to a profession or calling. As a veterinary scientist I am not less or more able to philosophise than Mr. Thornton, the scholar. Glib statements like Mr. Bongard's " no man's life ends at death, unlike the life of an animal which certainly does " fill us with misgivings, especially as in the case of Mr. Thornton, when they are " principles." For now they are treated like " knowledge " by the average person and may be easily transferred to " dogma "—as I suspect Mr. Bongard does—and this surely becomes a poor substitute for reality. Statements of whatever kind demand discussion. Remember there are *always* two possibilities and only one is truth which by discussion is itself again open to two possibilities—*ad infinitum*!

Honesty must recognise the untruth of total judgment which rests on inadequate knowledge. The " ultimate " in the world cannot be achieved if we call ourselves " free." Temporal manifestation and eternal being must meet in this imperfect world to make " reality " one of empirical existence. Consequently no *direct* knowledge of God is possible. Only faith is left and thus only unlimited devotion to God can be called true living. In this devotion the rights of animals and our obligations towards them *must* be recognised.

Yours faithfully,
J. H. WILKINS,
Major.

Albert Lodge,
Alexandra Road,
Farnborough,
Hants.

October 20th, 1957.

Sir,—It seems to me that Mr. Thornton (September 28th and October 19th), whether as a philosopher who is a Christian, or a Christian who is a philosopher, has bogged himself in sophistry by asking himself an unreal question—have animals " rights "? In the world of reality, the world of how and why, of observed facts and spiritual values, man has duties not rights. He alone amongst creatures has duties because he alone was made a spiritual animal by a transcendent and imminent God, who can never be regarded as organic with, or limited by, His creation.

Man's duty to animals was revealed by Our Lord's teaching 2,000 years ago: " Thou shalt love the Lord thy God with all thy heart and mind and soul and strength and thy neighbour as thyself." To love God is so simple and so very difficult. Despite the difficulties a veterinary surgeon, a farmer, a deep-sea fisherman, a slaughterman, a game-keeper, *et al.*, who does his work honestly, trustworthily, skilfully, to the glory of God, can hope that he is dutifully following the Lord Jesus. Whatever his profession the good man will act rightly, the bad will not; from within, out of the heart of man, come all the things which can exalt or degrade him.

If this is not truth I know it not. It, the theocentric teaching of the Lord Jesus, goes to the heart of the matter. In the discharge of his obligations to animals it is man's motive which is judged by God.

Yours faithfully,
TOM HARE.

529a, Finchley Road,
London, N.W.3.

October 21st, 1957.

The Fox as a Host of Echinococcus Spp and its Possible Rôle in the Spread of Hydatid Disease

Sir,—Sinclair, in his letter (*Vet. Rec.* **68.** 104), reports finding 5 foxes infected with *Echinococcus granulosus* in Wales. He suggests that rabbits may be the main intermediate hosts and intimates that now myxomatosis has reduced the rabbit population, this parasite may decrease in foxes.

In this letter, it is proposed briefly to review parts of an extensive literature on vulpine echinococciasis and point out certain facts which might usefully form the basis for further research in view of a possible increase in hydatid disease in Great Britain.

Firstly, I wish to point out that rabbits are not normally regarded as suitable intermediate hosts of Echinococcus spp and secondly, that the species of Echinococcus referred to by Sinclair may not be *E. granulosus* for the following reasons:—

1. Recently, Vogel (1955) and Rausch (1951-7) have shown that a species of Echinococcus, previously unknown, is frequently found in red foxes (*Vulpes vulpes*) in Europe (Vogel), in red foxes and Arctic foxes (*Alopes lagopus*) in Alaska, St. Lawrence Island, Nunivak Island, and Bering Island of the Commander group in the Bering Sea (Rausch). Besides boreal regions and Eurasia, the parasite has now been recorded in Simushir Island of the Kuriles and in the Japanese island of Rebun (Yamashita, 1956). This species *E. multilocularis* (Leuckart, 1863), syn. *E. sibiricensis* (Rausch & Schiller, 1954), syn. *E. alveolaris* (Klemm, 1883) is quite distinct from *E. granulosus* (Batsch, 1786; Rudolphi, 1805) by virtue of the host species naturally parasitised in its larval stage (*Microtus*,

Lemmus, and *Chlethrionomus*) and the characteristic growth of the cyst in man and these animals.

2. Many observations have been made on the parasites of foxes in different parts of the world where *E. granulosus* is endemic in the domestic and wild Canidae. In none of these regions has the fox been incriminated as a host of *E. granulosus*. For instance, Erickson (1944) reviewed the parasites of foxes in North America and does not record the parasite in this animal, although wolves (*Canis lupus*) in the same regions were natural hosts. In Australia, a classical home of *E. granulosus*, the European red fox, originally imported from Great Britain and now widespread throughout each state with the exception of Tasmania, plays no part in the spread of hydatid disease, although in some regions 25 per cent. of the domestic dogs and 40 per cent. of the Dingoes (*Canis dingo*) are affected with this parasite.

3. Attempts have been made to infest foxes with *E. granulosus* by Southwell (1927) in Great Britain, by Mattof and Jantscheft (1954) and Boray (1957) in Hungary, and Drezancic and Wikerhauser (1956) in Yugoslavia. All writers indicate that the fox is capable of harbouring *E. granulosus* for a period, but the parasite fails to develop normal segments or reach sexual maturity. This work has recently been repeated using the Australian strain of *E. granulosus* in 16 foxes, with identical results.

The fact than in these 5 experiments in widely separated parts of the world, *E. granulosus* failed to reach sexual maturity in foxes and the fact that it is not found in natural infestations in endemic areas, indicates quite clearly that the fox is not a definitive host of *E. granulosus* and consequently plays no rôle in the spread of hydatid disease.

The only records of *E. granulosus* being observed in the fox (other than Sinclair's) are those of Brailsford (1926) and Cameron (1926), both of whom observed this parasite in animals in Great Britain. Brailsford, without detailed examination or description, assumed the species to be *E. granulosus* and his record is therefore open to question. Cameron's description of *E. granulosus* found in a fox (fed on horse meat) at the London Zoological Gardens is of particular interest, as he describes many gravid segments. Ortlepp (1934), on re-examination of the material, suggested, on the basis of hook size and shape and the size and number of segments, that the species was not *E. granulosus*. He designated this parasite *E. cameroni*. Although the criteria used by Ortlepp to reclassify a parasite of the genus Echinococcus are open to question, in view of the experimental findings there are certainly grounds for accepting his opinion. It is possible, however, that occasionally *E. granulosus* may adapt itself sufficiently to an unsuitable host to develop sexually. This might be the case with Cameron's material. If this is the explanation, Cameron's is the only valid observation of gravid segments of *E. granulosus* in the fox. It is probable that this original reference has perpetuated the general belief that the fox is a definitive host of *E. granulosus* in Great Britain.

There is no doubt, however, that *E. granulosus* occurs in Great Britain, but it probably occurs only in a domestic cycle, the incidence of which is low, by virtue of the fact that raw sheep or pig offal does not normally form much part of the diet of the domestic dog in most districts. Miller and Poynter (1956) recently recorded this parasite in the horse. Although they describe cysts proliferating by exogenous budding judging by the photographs and general description given, the lesions appear to be the normal and typical forms of development of the larval stage of *E. granulosus* in the horse. It is quite possible that the horse may be a host to both larval species (see Baxter *et al.*, 1956).

Because of the confusion which has occurred between *E. granulosus* and *E. multilocularis*, it seems desirable that the term " exogenous budding " should be confined to growth of the larva of *E. multilocularis*, as this form of development does not occur in the growth of the larval form of *E. granulosus*.

The question arises, therefore, if the species recorded by Sinclair is not *E. granulosus*—what is it? This is not an academic question, but one of fundamental importance from epidemiological and public health aspects as will now be pointed out.

As *E. multilocularis*, in its larval stage, infests microtine rodents, giving rise to a characteristic form by exogenous budding, and as both the final hosts (dog and fox) and suitable intermediate hosts (*e.g.* Microtus spp) for this sylvatic cycle are present in Great Britain and, furthermore, autochthonus cases of alveolar hydatid disease have been recorded in man, it is reasonable to suggest that the parasites recorded in the fox by Sinclair may be *E. multilocularis*. If this is the case, Sinclair's suggestion that hydatid disease will decrease now that myxomatosis has reduced the rabbit population is untenable, as the fox will have to rely more and more on microtine rodents as a source of food and thus *ipso facto* increase the incidence of this parasite. Furthermore, the shortage of food for foxes may give rise to a closer contact between fox and man. It is suggested that instead of a decrease, there may be an increase of alveolar hydatid disease in man in the next decade in Great Britain, as has occurred since the introduction of this parasite into the Japanese island of Rebun.

It is hoped that this letter may stimulate work in the field and laboratory to clarify the epizootiology of this parasitic zoonosis.

Yours faithfully,

MICHAEL A. GEMMELL,
Director.

Hydatid Research Unit,
Faculty of Medicine,
University of Otago,
Dunedin,
New Zealand.

October 20th, 1957.

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Aphosphorosis and Infertility

Sir,—I am most interested in the letters from Messrs. Mullins and Ramsay and from Mr. Lloyd, which appeared in your issues of September 28th and October 12th, respectively. Although a number of workers, *e.g.* Theiler, Green, and du Toit (1924), have reported that impaired fertility in cattle is associated with clinical aphosphorosis, the observations of your correspondents do not surprise my colleagues and me because we appreciate that the phosphorus intake alone does not determine fertility.

Since the criteria of reproductive efficiency vary widely it would be interesting to have further information about the two herds—the percentages of animals which held to a first service, the numbers of services required per pregnancy, and, most important of all, the average inter-calving periods. Data regarding growth rates and milk yields in the herds would be valuable additional information.

Although our earlier planned feeding experiments supported the view based on an extensive survey (Hignett & Hignett, 1951) that bovine fertility can be related to the oral consumption of phosphorus, we certainly have accepted that the relationship can be upset by the calcium intake (Hignett & Hignett, 1951), by the vitamin D status (Hignett & Hignett, 1953), and by the manganese intake (Hignett, 1956).

For some years we have been particularly interested in the influence of manganese because certain planned feeding experiments directed to cover other factors, including the plane of nutrition, suggested that additional manganese favourably affected the fertility when phosphorus intake was relatively low, consequently a further experiment was undertaken. Ten heifers were placed on a ration of low nutritional value giving a daily phosphorus (P_2O_5) intake of only 5 g. per 100 lb. bodyweight and providing less than 40 mg. elemental manganese per 100 lb. bodyweight. Half of these animals received a supplement of manganese sulphate sufficient to ensure an elemental manganese consumption of 40 to 60 mg. per 100 lb. bodyweight. The results are shown in the following table and indicate that, even on a low plane of nutrition with a relatively low phosphorus intake, the addition of manganese leads to a marked improvement in fertility.

EFFECT OF MANGANESE INTAKE ON HEIFER FERTILITY

Manganese Intake	A	B	C
< 40 mg. per 100 lb.	1/5	3.0	96.3
> 40 mg. per 100 lb.	5/5	1.0	13.2

A = Animals holding to a first service/animals served.
B = Average number of services per pregnancy.
C = Average time prior to successful service (days).

It was this and subsequent observations which led me to present data in a recent paper (Hignett, 1956), which your correspondents have probably not yet seen, suggesting that the intakes of phosphorus and manganese may well be complementary in their effect on fertility in cattle. Certainly there are a number of factors which determine the amount of phosphorus required for reproductive efficiency—probably quite a complex of the calcium, phosphorus, manganese, vitamin D intakes; even the plane of nutrition and carotene may be involved. If the manganese intake is high, fertility may be normal when phosphorus consumption is obviously low and the demand for these two elements is considerably reduced if calcium consumption is low, particularly where the growth rate is negligible and, in the case of the lactating animal, milk yield is small.

Although knowledge of the associated factors is growing and much work remains to be done, we still believe a daily phosphorus intake of 50 g. P_2O_5 for maintenance and about 20 g. for each gallon of milk, with a calcium consumption (in terms of CaO) well in excess of phosphorus (in terms of P_2O_5), is both practicable and desirable to maintain a high level of fertility in dairy cows kept under prevailing conditions in this country.

Mr. Lloyd will appreciate that reference to calcium-phosphorus ratios in our publications relates to dietary levels and not blood levels of these elements.

Yours faithfully,
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